U.S. Department
of Transportation
Federal Aviation Administration

Office of Airport Safety and Standards
Airport Engineering Division AAS-100

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The attached is draft update to Federal Aviation Administration (FAA) Advisory Circular (AC) 150/5380-6A *Guidelines And Procedures For Maintenance Of Airport Pavements.* Principal changes included in this update are as follows:

1. Procedures and methodology to determine the Pavement Condition Index (PCI) have been removed from the AC and referenced to the current industry standard (ASTM D 5340, Test Method For Airport Pavement Condition Surveys).

2. Provide guidance on minimum inspection and maintenance programs in accordance with Program Guidance Letter 95-2.

3. Update equipment and maintenance procedures to current industry practice.

U.S. Department
of Transportation

**Federal Aviation
Administration**

Advisory Circular

Subject: GUIDELINES AND PROCEDURES FOR MAINTENANCE OF AIRPORT PAVEMENTS	**Date: DRAFT** **Initiated by:** AAS-100	**AC No:** 150/5380-6A **Change:**

1. PURPOSE. This Advisory Circular (AC) provides guidelines and procedures for maintenance of rigid and flexible airport pavements.

2. CANCELLATION. AC 150/5380-6, Guidelines and Procedures for Maintenance of Airport Pavements, dated 12/3/82, is cancelled.

3. APPLICATION. The guidelines contained herein are recommended for airport pavements as appropriate.

4. RELATED READING MATERIAL. The publications in Appendix 2, bibliography, provide further guidance and technical information.

Director, Office of Airport Safety and Standards

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CHAPTER 1. INTRODUCTION TO AIRPORT PAVEMENT MAINTENANCE.

1-1. PURPOSE OF ADVISORY CIRCULAR. Airport managers and technical/maintenance personnel responsible for operation and maintenance of airports, continually face problems involving pavement distress and deterioration. This advisory circular (AC) provides information on the types of pavement distress and recommended corrective actions to assist them in undertaking preventive and remedial maintenance. ASTM D5340 *Standard Test Method for Airport Pavement Condition Index Survey*s is the recommended procedure for conducting preventive maintenance inspections. This standard employs the visual distress identification and rating system known as the Pavement Condition Index (PCI).

1-2. BACKGROUND OF ADVISORY CIRCULAR. The aviation community has a large investment in airport pavements. The major objective in the design and construction of these pavements is to provide adequate load-carrying capacity and good ride-quality which permit safe operation of aircraft under all weather conditions. Immediately upon completion of construction, airport pavements begin a gradual deterioration which is attributable to several factors. Traffic loads in excess of those forecast during pavement design can shorten pavement life considerably. Normal distresses in the pavement structure result from surface weathering, fatigue effects, and differential movement in the underlying subbase over a period of years. In addition, faulty construction techniques, substandard materials, or poor workmanship can accelerate the pavement deterioration process. Consequently, there is a continual requirement to perform routine maintenance, rehabilitation, and upgrading of existing airport pavements.

a. Many pavements were not designed for servicing today's aircraft which impose loads much greater than those initially considered. Also, there may have been a considerable increase in the frequency of takeoffs and landings. Both factors result in accelerated deterioration of the pavement structure. Thus, special efforts must be made to upgrade and maintain pavement serviceability to assure safe airport operations.

b. The most effective means of preserving airport runways, taxiways, and apron pavement areas is the implementation of a comprehensive maintenance program. Such a program is a coordinated, budgeted, and systematic approach to both preventive and remedial maintenance. A number of airports have developed this concept and have experienced tangible benefits. An update to the comprehensive maintenance program should be developed annually, featuring a time schedule and listing equipment and products required. Repairs and preventive measures should be made systematically each year to the extent necessary. A systematic approach assures continual vigilance and permits maintenance materials to be stockpiled, thereby assuring availability for routine and emergency maintenance.

c. Two major elements contributing to pavement deterioration are the gradual effects of weathering and the action of aircraft traffic. Failure to perform routine maintenance during the early stages of deterioration, may result in extensive repairs at a later date. This type of neglect is costly, not only in terms of dollars, but also in terms of closure time. Early detection and repair of pavement defects is the most important preventive maintenance procedure. Cracks and other surface defects, which at their early stages are almost unnoticeable, may develop into serious pavement distresses if not repaired. In all cases of pavement distress manifestations, the causes of the problem should first be determined. Repairs can then be made which will not only correct the present damage but will also prevent or retard its progressive occurrence.

d. The selection of a specific rehabilitation method involves both economic and engineering considerations. Maintenance and repair of airport pavements should consider the long-term effects, rather than immediate short-term remedies. Compare the cost of rehabilitation alternatives over some finite period of time (life cycle). In addition to the initial rehabilitating maintenance costs consider all economic consequences, both the present and future of a given repair method.

e. The present or immediate costs of a pavement rehabilitation/maintenance project include actual costs of the repairs together with the estimated costs that will be incurred by the airport users as a result of the project. Airport user costs include those experienced by airlines, fixed base operators, concession operators, etc., due to traffic delays, reroutings, etc.. Future costs involve similar costs incurred later during the life-cycle period (depending on the life expectancy of the repair) plus the routine maintenance costs anticipated over the same period. A comparative analysis of these costs for the various alternatives will indicate the rehabilitation scheme that is the most economical.

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CHAPTER 2. AIRPORT PAVEMENTS: COMPOSITION AND FUNCTION.

2-1. INTRODUCTION TO AIRPORT PAVEMENTS. Airport pavements are designed, constructed, and maintained to support the critical loads imposed on the pavement and to produce a smooth and safe riding surface. The pavement must be of such quality and thickness that it will not fail under the loads imposed and be sufficiently durable to withstand the abrasive action of traffic, adverse weather conditions, and other deteriorating influences. In order to ensure the necessary strength of the pavement and to prevent unmanageable distresses from developing, various design, construction, and material-related parameters must be considered. To assess such parameters, this chapter provides information on the composition of pavement sections and the functional aspects of flexible and rigid pavement components.

2-2. CLASSIFICATION OF AIRFIELD PAVEMENTS. Generally, pavements are divided into the following three classes:

a. Rigid pavements

b. Flexible pavements

c. Overlay pavements

Combinations of different pavement types and stabilized layers constitute complex pavements that can be classified as variations of the normal rigid and flexible types.

2-3. RIGID PAVEMENT COMPOSITION AND STRUCTURE. Rigid pavements normally involve the use of portland cement concrete (PCC) as the prime structural element. Depending upon conditions, the pavement slab may be designed with plain, lightly reinforced, continuously reinforced, prestressed, or fibrous concrete. The concrete slab is usually placed on a compacted granular or treated subbase, which, in turn, is supported by a compacted subgrade. The subbase provides uniform stable support and may provide subsurface drainage. The concrete slab has considerable flexural strength and spreads the applied loads over a large area. Figure 2-1 illustrates a typical rigid pavement structure. Rigid pavements possess a high degree of rigidity. Figure 2-2 illustrates how this rigidity and resulting beam action enables rigid pavements to distribute loads over large areas of the subgrade. For better pavement performance, it is important that support for the concrete slab be uniform. Rigid pavement strength is most economically built into the concrete slab itself with optimum use of low-cost materials under the slab.

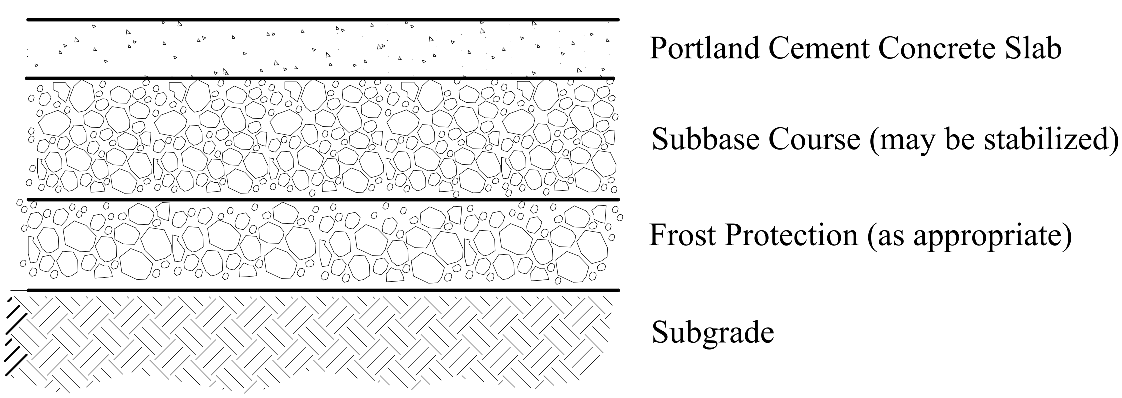

FIGURE 2-1. TYPICAL RIGID PAVEMENT STRUCTURE

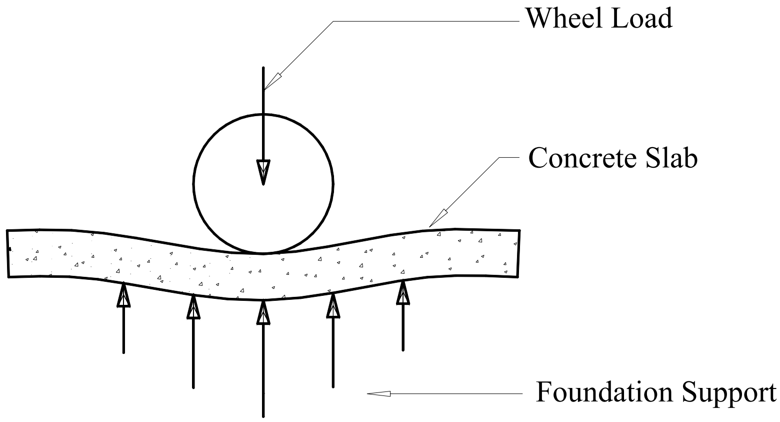

FIGURE 2-2. TRANSFER OF WHEEL LOAD TO FOUNDATION IN RIGID PAVEMENT STRUCTURE.

a. Concrete Slab (Surface Layer). The purpose of the concrete slab is to provide structural support to the aircraft, provide a skid-resistant surface, and prevent the infiltration of surface water into the subbase.

b. Subbase. The purpose of the subbase is to provide uniform stable support for the pavement slab. A minimum subbase thickness of 4 inches (100 mm) is generally required under rigid pavements. Other functions of the subbase are to (1) control frost action, (2) provide subsurface drainage, (3) control swell of subgrade soils, (4) provide a stable construction platform for rigid pavement construction, and (5) to prevent mud pumping of fine-grained soils.

c. Stabilized Subbase. A stabilized subbase is required for all new rigid pavements designed to accommodate aircraft weighing 100,000 pounds (45 350 kg) or more. The structural benefit imparted to a pavement section by a stabilized subbase is reflected in the modulus of subgrade reaction assigned to the foundation.

d. Frost Protection Layer. Frost action is an important environmental consideration in areas where there are freezing temperatures and frost-susceptible soil with a high ground water table. Frost action includes both frost heave and loss of subgrade support during the frost-melt period. Frost heave may cause a portion of the pavement to rise due to nonuniform formation of ice crystals in a frost-susceptible material (see Figure 2-3). Thawing of the frozen soil and ice crystals during the spring period may cause pavement damage under loads. The main purpose of the frost protection layer is to function as a barrier against frost action and frost penetration into the lower frost-susceptible layers.

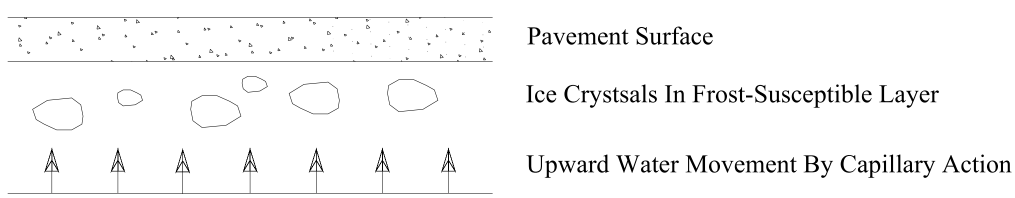

FIGURE 2-3. FORMATION OF ICE CRYSTALS IN THE SOIL.

e. Subgrade. The subgrade is the compacted soil layer which forms the foundation for the pavement system. Subgrade soils are subjected to lower stresses than the surface and subbase courses. These stresses decrease with depth, and the controlling subgrade stress is usually at the top of the subgrade unless unusual conditions exist. Unusual conditions, such as a layered subgrade or sharply varying water content or densities, may change the locations of the controlling stress. These conditions are checked during the soils investigation. The pavement above the subgrade must be capable of reducing stresses imposed on the subgrade to values which are sufficiently low to prevent excessive distortion or displacement of the subgrade soil layer. Since subgrade soils vary considerably, the interrelationship of texture, density, moisture content, and strength of subgrade material is complex. The ability of a particular soil to resist shear and deformation will vary with its density and moisture content. In this regard, the soil profile of the subgrade requires careful examination. The soil profile is the vertical arrangement of layers of soils, each of which may possess different properties and conditions. Soil conditions are related to the ground water level, presence of water-bearing strata, and the properties of the soil, including soil density, particle size, moisture content, and frost penetration. Since the subgrade soil supports the pavement and the loads imposed on the pavement surface, it is critical to investigate soil conditions to determine their effect on grading and paving operations, and the necessity for underdrains.

2-4. FLEXIBLE PAVEMENT COMPOSITION AND STRUCTURE. Flexible pavements support loads through bearing rather than flexural action. They are comprised of several layers of carefully selected materials designed to gradually distribute loads from the pavement surface to the layers underneath. The design is such that the load transmitted to each successive layer does not exceed the layer's load-bearing capacity. A typical flexible pavement section is shown in Figure 2-4. Figure 2-5 depicts the distribution of the imposed load to the subgrade. The various layers comprising a flexible pavement and the functions they perform are described below:

a. Bituminous Surface (Wearing Course). The bituminous surface, or wearing course, is comprised of a mixture of various selected aggregates bound together with asphalt cement or other bituminous binders. Its function is to prevent the penetration of surface water to the base course, provide a smooth, well-bonded surface free from loose particles (which might endanger aircraft or persons), resist the stresses developed as a result of aircraft loads, and furnish a skid-resistant surface without causing undue wear on tires.

b. Base Course. The base course is the principal structural component of the flexible pavement. It functions to distribute the imposed wheel load to the pavement foundation, the subbase and/or subgrade. The base course must be designed of a quality and thickness to prevent failure in the subgrade and/or subbase, withstand the stresses produced in the base itself, resist vertical pressures that tend to produce consolidation and result in distortion of the surface course, and resist volume changes caused by fluctuations in its moisture content. The materials comprising the base course are select hard and durable aggregates which generally fall into two main classes: stabilized and granular. The stabilized bases normally consist of crushed or uncrushed aggregate bound with a stabilizer such as portland cement or bitumen. The quality of the base course is a function of its composition, physical properties, and compaction of the material.

c. Subbase. This layer is used in areas where frost action is severe or in locations where the subgrade soil is extremely weak. The function of the subbase course is similar to the base course. The material requirements for the subbase are not as strict as those for the base course since the subbase is subjected to lower load stresses. The subbase consists of stabilized or properly compacted granular material.

d. Frost Protection Layer. A frost protection layer may be required in a flexible pavement. Its function is the same in either a flexible or a rigid pavement. (See paragraph 2-3 d.)

e. Subgrade. The subgrade is the compacted soil layer that forms the foundation for the pavement system. Subgrade soils are subjected to lower stresses than the surface, base, and subbase courses. Since load stresses decrease with depth, the controlling subgrade stress is usually at the top of the subgrade. The combined thickness of subbase, base, and wearing surface must be great enough to reduce the stresses occurring in the subgrade to values which will not cause excessive distortion or displacement of the subgrade soil layer. Factors affecting subgrade behavior are discussed in paragraph 2-3 e.

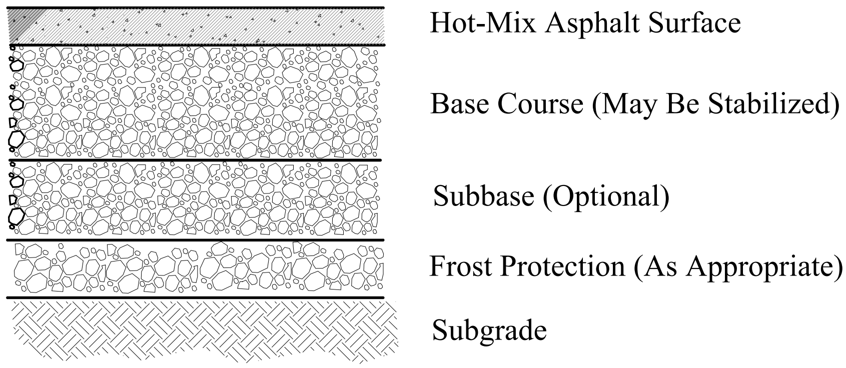

FIGURE 2-4. TYPICAL FLEXIBLE PAVEMENT STRUCTURE.

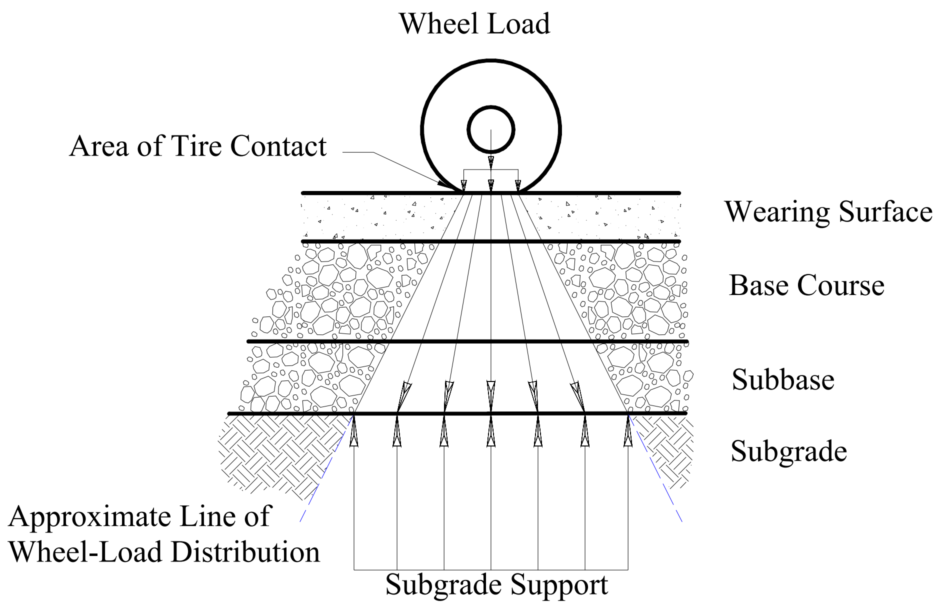

FIGURE 2-5. DISTRIBUTION OF LOAD STRESS IN FLEXIBLE PAVEMENT.

2-5. AIRPORT PAVEMENT OVERLAYS. Airport pavement overlays are usually undertaken to correct deteriorating pavement surfaces, to improve ride quality or surface drainage, to maintain the structural integrity, or to increase pavement strength. For instance, a pavement may have been damaged by overloading; it may require strengthening to serve heavier aircraft; uneven settling may have caused severe puddling; or the original pavement simply may have served its design life and is worn out. Airport pavement overlays generally consist of either portland cement concrete or bituminous concrete.

CHAPTER 3. PAVEMENT DISTRESS.

3-1. GENERAL. The deterioration of a pavement, be it runway or highway, is made apparent by various external signs or indicators which can be associated with the probable causes of the failure. This chapter provides a detailed discussion and description of the types of pavement distress relating them to likely causal factors..

3-2. TYPES OF PAVEMENT DISTRESS. The discussions of problems related to pavement distress are generally based on the pavement type; concrete or bituminous. However, while each possesses its own particular characteristics, the various types of pavement distress for bituminous and concrete pavements generally fall into one of the following broad categories:

a. Cracking

b. Distortion

c. Disintegration

d. Loss of Skid resistance

3-3. CONCRETE PAVEMENT DISTRESSES.

a. Cracking. Cracks in concrete pavements often result from stresses caused by expansion and contraction or warping of the pavement. Overloading, loss of subgrade support, insufficient and/or improperly cut joints acting singularly or in combination are also possible causes.

(1) Longitudinal, Transverse, and Diagonal Cracks. The usual cause is a combination of repeated loads and shrinkage stresses, and is characterized by cracks that divide the slab into two or three pieces. These types of distress can be an indication of poor construction techniques.

(2) Corner Breaks. Load repetition, combined with loss of support and curling stresses, usually cause cracks at the slab corner. The lack of support may be caused by pumping or loss of load transfer at the joint. This type of break is characterized by a crack that intersects the joints at a distance less than or equal to one-half of the slab length on both sides, measured from the corner of the slab. A corner crack differs from a corner spall in that the crack extends vertically through the entire slab thickness, while a corner spall intersects the joint at an angle.

(3) Durability "D" Cracking. "D" cracking usually appears as a pattern of cracks running in the vicinity of and parallel to a joint or linear crack. It is caused by the concrete's inability to withstand environmental factors such as freeze-thaw cycles due to variable expansive aggregates. This type of cracking may eventually lead to disintegration of the concrete within 1 to 2 feet (300 to 600 mm) of the joint or crack.

(4) Joint Seal Damage. Joint seal damage is any condition which enables soil or rocks to accumulate in the joints or allows infiltration of water. Accumulation of materials prevents the slabs from expanding and may result in buckling, shattering, or spalling. Water infiltration through joint seal damage can cause pumping or deterioration of the subbase. Typical types of joint seal damage include stripping of joint sealant, extrusion of joint sealant, hardening of the filler (oxidation), loss of bond to the slab edges, and absence of sealant in the joint. Joint seal damage is caused by improper joint width, use of the wrong type of sealant, incorrect application, and/or not properly cleaning the joint before sealing.

b. Disintegration. Disintegration is the breaking up of a pavement into small, loose particles and is caused by improper curing and finishing of the concrete, unsuitable aggregates, and improper mixing of the concrete. It also includes dislodging of aggregate particles.

(1) Scaling, Map Cracking, Crazing. Map cracking or crazing refers to a network of shallow hairline cracks that extend only through the upper surface of the concrete. Crazing usually results from improper curing and/or finishing of the concrete and may lead to scaling of the surface. Scaling is the disintegration and loss of the wearing surface. Scaling may also be caused by a weakened surface caused by improper curing or finishing, and freeze-thaw cycles. Alkali-Silica Reactivity (ASR) is another source of distress associated with scaling. Deterioration is caused by an expansive reaction between reactive aggregates and the alkaline pore solutions in the concrete.

(2) Joint Spalling. Joint spalling is the breakdown of the slab edges within 2 feet (600 mm) of the side of the joint. A joint spall usually does not extend vertically through the slab but intersects the joint at an angle. Joint spalling often results from excessive stresses at the joint or crack caused by infiltration of incompressible materials. Weak concrete at the joint (caused by overworking) combined with traffic loads is another cause of spalling. Joint spalling can also result from misaligned dowels, which can prevent slab movement, either through improper placement of dowels or improper slippage preparation for the dowel.

(3) Corner Spalling. Corner spalling is the raveling or breakdown of the slab within approximately 2 feet (600 mm) of the corner. It differs from a corner break in that the spall usually angles downward to intersect the joint, while a break extends vertically through the slab. Corner spalling is often caused by the same mechanism as joint spalling but may be observed sooner due to increased exposure.

(4) Blowups. Blowups usually occur at a transverse crack or joint. It generally occurs in hot weather due to additional thermal expansion of the concrete. Blowups usually occur at a transverse crack or joint that is not wide enough to permit expansion of the concrete slabs. Insufficient width may be due to infiltration of incompressible materials into the joint space or by gradual closure of the joint caused by expansion of the concrete due to ASR. When expansion pressure cannot be relieved, a localized upward movement of the slab edges (buckling) or shattering will occur in the vicinity of the joint. Blowups normally occur only in thin pavement sections, although blowups can also be experienced at drainage structures (manholes, inlets, etc.). The frequency and severity of blowups may increase with an asphalt overlay due to the additional heat absorbed by the dark asphalt surface.

(5) Shattered Slab. A shattered slab is defined as a slab where intersecting cracks break up the slab into four or more pieces. This is caused by overloading and/or inadequate foundation support.

c. Distortion. Distortion is a change in the pavement surface from its original position and results from foundation settlement, expansive soils, frost susceptible soils, or loss of fines through improperly designed subdrains or drainage systems.

(1) Pumping. Pumping is characterized by the ejection of water and subgrade (or subbase) material through the joints or cracks in a pavement, caused by deflection of the slab when loaded. As the water is ejected, it carries particles of gravel, sand, clay, or silt resulting in a progressive loss of pavement support that can lead to cracking. Surface staining and base or subgrade material on the pavement close to joints or cracks are evidence of pumping. Pumping near joints indicates a poor joint seal and/or the presence of ground water.

(2) Settlement or Faulting. Settlement or faulting is a difference in elevation at a joint or crack caused by upheaval or non-uniform consolidation of the subgrade or subbase material. This condition may result from loss of fines, from frost heave, loss of load transfer device (key, dowel, etc.), or from swelling soils.

d. Skid Resistance. Skid resistance refers to the ability of a pavement to provide a surface with the desired friction characteristics under all weather conditions and is a function of the surface texture or the buildup of contaminants.

(1) Polished Aggregates. Some aggregates will become polished quickly under traffic. Others are naturally polished and will be a skid hazard if used in the pavement without crushing.

(2) Contaminants. Rubber deposits building up over a period of time will reduce the surface friction characteristics of a pavement. Oil spills and other contaminates will also reduce the surface friction characteristics.

3-4. BITUMINOUS PAVEMENT DISTRESSES

a. Cracking. Cracks in bituminous pavements are caused by deflection of the surface over an unstable foundation, shrinkage of the surface, thermal expansion and contraction of the surface, poorly constructed lane joints, or reflection cracking.

(1) Longitudinal and Transverse Cracks. Longitudinal and transverse cracks are caused by shrinkage or contraction of the bituminous concrete surface. Shrinkage of the surface material is caused by oxidation and age hardening of the asphalt material. Contraction is due to thermal changes. Development of longitudinal cracks may be accelerated due to poorly constructed lane joints.

(2) Alligator or Fatigue Cracking. Alligator cracks are interconnected cracks that form a series of small blocks resembling an alligator skin. They may be caused by fatigue failure of the bituminous surface under repeated loading or by excessive deflection of the asphalt surface over an unstable or weak foundation. The unstable support is usually the result of water saturation of the bases or subgrade.

(3) Block Cracking. Shrinkage of the asphalt concrete and daily temperature cycling (which results in daily stress/strain cycling) causes block cracking. These are interconnected cracks that divide the pavement into approximately rectangular pieces. The occurrence of this distress usually indicates that the asphalt has hardened significantly. Block cracking generally occurs over a large portion of the pavement area and may sometimes occur only in nontraffic areas.

(4) Slippage Cracks. Slippage cracks are caused by braking or turning wheels causing the pavement surface to slide and deform. This usually occurs when there is a low-strength surface mix or poor bond between the surface and the next layer of pavement structure. These cracks are crescent or half-moon-shaped cracks having two ends pointed away from the direction of traffic.

(5) Reflection Cracking. Reflection cracks are caused by vertical or horizontal movements in the pavement beneath an overlay, brought on by expansion and contraction with temperature and moisture changes. These cracks in asphalt overlays reflect the crack pattern in the underlying pavement. They occur most frequently in asphalt overlays on portland cement concrete pavements. However, they may also occur on overlays of asphalt pavements wherever cracks in the old pavement have not been properly repaired.

b. Disintegration. Disintegration in a bituminous pavement is caused by insufficient compaction of the surface, insufficient asphalt in the mix, loss of adhesion between the asphalt coating and aggregate particles, or overheating of the mix.

(1) Raveling. Raveling is the wearing away of the pavement surface caused by the dislodging of aggregate particles and loss of asphalt binder. As the raveling continues, larger pieces are broken free, and the pavement takes on a rough and jagged appearance.

c. Distortion. Distortion in bituminous pavements is caused by foundation settlement, insufficient compaction of the pavement courses, lack of stability in the bituminous mix, poor bond between the surface and the underlying layer of the pavement structure, swelling soils or frost action in the subgrade.

(1) Rutting. A rut is characterized as a surface depression in the wheel path. In many instances, ruts are noticeable only after a rainfall when the wheel paths are filled with water. This type of distress is caused by a permanent deformation in any of the pavement layers or subgrade and is caused by consolidation or displacement of the materials due to traffic loads.

(2) Corrugation and Shoving. Corrugation results from a form of plastic surface movement typified by ripples across the surface. Shoving is a form of plastic movement resulting in localized bulging of the pavement surface. Corrugation and shoving can be caused by lack of stability in the mix and poor bond between material layers.

(3) Depression. Depressions are localized low areas of limited size. In many instances, light depressions are not noticeable until after a rain, when ponding creates "birdbath" areas. Depressions can be caused by traffic heavier than that for which the pavement was designed, by localized settlement of the underlying pavement layers, or by poor construction methods.

(4) Swelling. An upward bulge in the pavement's surface characterizes swelling. It may occur sharply over a small area or as a longer gradual wave. Both types of swell may be accompanied by surface cracking. A swell is usually caused by frost action in the subgrade or by swelling soil.

d. Loss of Skid Resistance. Factors which decrease the skid resistance of a pavement surface and can lead to hydroplaning include: too much asphalt in the bituminous mix; too heavy a tack coat; poor aggregate subject to wear; and buildup of contaminants.

(1) Bleeding. Bleeding is characterized by a film of bituminous material on the pavement surface which resembles a shiny, glass-like, reflecting surface that usually becomes quite sticky. It is caused by excessive amounts of asphalt cement or tars in the mix and/or low air-void content and occurs when asphalt fills the voids in the mix during hot weather and then expands out onto the surface of the pavement. Since the bleeding process is not reversible during cold weather, asphalt or tar will accumulate on the surface. Extensive bleeding may cause a severe reduction in skid resistance.

(2) Polished Aggregate. Aggregate polishing is caused by repeated traffic applications. It occurs when the aggregate extending above the asphalt is either very small, of poor quality, or contains no rough or angular particles to provide good skid resistance.

(3) Fuel Spillage. Continuous fuel spillage on a bituminous surface will soften the asphalt. Areas subject to only minor fuel spillage will usually heal without repair, and only minor damage will result.

(4) Contaminants. Accumulation of rubber on the pavement surface will reduce the skid resistance of a pavement. Build up of rubber deposits in pavement grooves will reduce the effectiveness of the grooves and increase the likelihood of hydroplaning.

3-5. DRAINAGE OF AIRPORT PAVEMENTS.

a. A proper drainage system is a fundamental consideration of preventive maintenance. Pavement failures should always be investigated for deficient drainage. Probably no other factor plays such an important role in determining the ability of a pavement to withstand the effects of weather and traffic. The purpose of airport drainage is to dispose of the water, which may hinder activity necessary to the safe and efficient operation of the airport. The drainage system collects and removes surface water runoff, removes excess underground water, lowers the water table, and protects all slopes from erosion. An inadequate drainage system can cause saturation of the subgrade and subbase, damage to slopes by erosion, and loss of the load-bearing capacity of the paved surfaces.

b. The damage mechanism of free water in the pavement system is related to the amount of free water in the boundaries between the structural layers of the pavement system. When water fills the voids and spaces at the boundaries between layers, heavy wheel loads applied to the surface of the pavement produce impacts on the water that are comparable to a water-hammer type of action. The resulting water pressure causes erosion of the pavement structure and ejection of the material out of the pavement.

c. There are two general classes of drainage systems, surface and subsurface. Classification depends on whether the water is on or below the surface of the ground at the point where it is first intercepted or collected for disposal. Where both types of drainage are required, it is generally good practice for each system to function independently.

(1) Surface Drainage. The purpose of the surface drainage is to control and collect water from rainstorms and melting snow and ice. Surface drainage of pavements is achieved by constructing the pavement surface and adjacent ground to allow for adequate runoff. Surface water may be collected at the edges of the paved surface in ditches, gutters, and catch basins. Surface drainage includes the disposal of all water present on the surface of the pavement and nearby ground. Surface water should not be allowed to enter a subdrainage system as it often contains soil particles in suspension. These particles deposit as the water percolates through the granular material of the subdrain causing it to silt up. Inevitably, some water will enter the pavement structure through cracks, open joints, and other surface openings, but this may be kept to a minimum by proper surface maintenance procedures.

(2) Subsurface Drainage. Subsurface drainage is provided for the pavement by a highly permeable layer of sand-aggregate mixture or permeable stabilized layers such as cement treated or asphalt treated layers under the full width of the traveled way, with longitudinal pipes for collecting the water, and outlet pipes for rapid removal of the water from the subsurface drainage system. Subsurface drains may also consist of perforated collection pipes or conduits in a permeable sand or gravel trench encased in geotextiles with outlet pipes. These systems remove excess water from pavement foundations to prevent weakening of the base and subgrade and to reduce damage from frost action. Subsurface drainage trenches placed at the pavement edge also prevent surface runoff moisture from entering the pavement structure from the pavement perimeter.

d. Additional guidance and technical information is contained in AC 150/5320-5, *Airport Drainage*, current edition.

CHAPTER 4. GUIDELINES FOR INSPECTION OF PAVEMENTS.

4-1. INTRODUCTION TO PAVEMENT INSPECTION. A high priority should be given to the upkeep and repair of all pavement surfaces in the aircraft operating areas of the airport to ensure continued safe aircraft operations. While deterioration of the pavements due to usage and exposure to the environment cannot be completely prevented, a timely and effective maintenance program can reduce this deterioration to a minimum level. Adequate and timely maintenance is the greatest single means or controlling pavement deterioration. Many cases are known where failures of airport pavements and drainage features were directly attributed to inadequate maintenance characterized by the absence of a vigorously followed inspection program. It should be noted that maintenance, no matter how effectively carried out, cannot overcome or compensate for a major design or construction inadequacy. It can, however, prevent the total and possibly disastrous failure which may result from such deficiencies. The maintenance inspection can reveal at an early stage where a problem exists and thus provide the warning and time to permit corrective action. Postponement of minor maintenance can develop into a major pavement repair project. This chapter presents guidelines and procedures for inspection of airport pavements.

4-2. INSPECTION PROCEDURES. Maintenance is a continuous function and is the responsibility of airport personnel. A series of scheduled, periodic inspections or surveys, conducted by experienced engineers, technicians, or maintenance personnel, must be carried out in a truly effective maintenance program. These surveys must be controlled to ensure that each element or feature being inspected is thoroughly checked, that potential problem areas are identified, and that proper corrective measures are recommended. The maintenance program must provide for adequate follow-up of the inspection to ascertain that the corrective work is expeditiously accomplished and recorded. Although the organization and scope of maintenance activities will vary in complexity and degree from airport to airport, the general types of maintenance are relatively the same regardless of airport size or extent of development.

a. Inspection Schedules. The supervisor of airport maintenance is responsible for establishing a schedule for inspections. Schedule inspections to ensure that all areas, particularly those which may not come under day-to-day observation, are thoroughly checked. Schedule thorough inspections of all paved areas at least twice a year. In temperate climates, schedule one inspection for spring and one for fall. Any severe storms or other conditions which may have an adverse effect on the pavement may also necessitate a thorough inspection. Solicit reports from airport users and conducted everyday drive-by type inspections in addition to scheduled inspections.

b. Record keeping. Record and file complete information concerning all inspections and maintenance performed. Document the severity level of existing distress types, their locations, their probable causes, remedial actions, and results of follow up inspection and maintenance. In addition, the file should contain information on potential problem areas and preventive or corrective measures identified. Records of materials and equipment used to perform all maintenance and repair work should also be kept on file for future reference. Such records may be used later in identifying materials and remedial measures which may reduce maintenance costs and improve pavement serviceability.

4-3. FRICTION SURVEYS. Maintain runway pavements to provide surfaces with good friction characteristics under all weather conditions. Parameters which affect the skid resistance of wet pavement surfaces include the following:

a. Texture depth

b. Rubber deposits

c. Paint marking

d. Pavement abnormalities such as rutting, raveling, and depression

Observations made during the pavement inspection will help determine if a friction survey is required. AC 150/5320-12, *Methods for the Design, Construction, and Maintenance of Skid Resistant Airport Pavement Surfaces*, current edition, provides guidance on conducting friction surveys.

4-4. NONDESTRUCTIVE TESTING. In addition to visual inspection of the pavement area and information on runway history, data from nondestructive testing is desirable. Such data are used to evaluate the pavement load-carrying capacity. Loads are applied to the pavement through loading plates or wheels, and the pavement deflection response is recorded. The stiffness or strength of the airport pavement can be related to the magnitude of these deflections. Nondestructive testing involves a large number of readings, and a statistical average is used. Details for taking the measurements and evaluating the test results to determine the load-carrying capacity of the pavement structure are contained in AC 150/5370-11, *Use of Nondestructive Testing Devices in the Evaluation of Airport Pavements*, current edition.

4-5. DRAINAGE SURVEYS. Adequate drainage of surface and ground water is an important consideration in the maintenance of airport pavements since water is directly or partly responsible for a large percentage of pavement failures and deterioration. Sufficient drainage for collection and disposal of surface runoff and excess ground water is vital to the stability and serviceability of pavement foundations. A periodic and complete inspection of drainage systems should be conducted by trained personnel and defective conditions of surface and subsurface drainage systems should be recorded and corrected. Runway and taxiway edge drains and catch basins should be inspected at intervals (i.e., spring, summer, fall, and winter seasons of the year) and monitored following unusually heavy rainfall. The personnel making the inspection should look for distress signals which may indicate impending problems. These distress signals include:

a. Ponding of water in undesirable areas

b. Soil buildup at pavement edge preventing runoff

c. Eroded ditches and spill basins

d. Broken or displaced inlet grates or manhole covers

e. Clogged or silted inlet grates and manhole covers

f. Blocked subsurface drainage outlets

g. Broken or deformed pipes

h. Backfill settlement over pipes

i. Erosion around inlets

j. Generally poor shoulder shaping and random erosion

k. Discoloration of pavement at joints or cracks

4-6. PAVEMENT MANAGEMENT SYSTEMS. One method of establishing an effective maintenance and repair system is through the use of a pavement management system (PMS). A PMS is defined as a systematic and consistent procedure for scheduling maintenance and rehabilitation based on maximizing benefits and minimizing costs. A pavement management system not only evaluates the present condition of a pavement but also can predict its future condition through the use of a pavement condition indicator. By projecting the rate of deterioration, a life-cycle cost analysis can be performed for various alternatives, and the optimal time of application of the best alternative is determined.

a. The primary component of any PMS is the ability to track a pavement's deterioration and determine the cause of the deterioration. This requires an evaluation process that is objective, systematic and repeatable. One such process is the Pavement Condition Index (PCI). The PCI is a rating of the surface condition of a pavement and is a measure of functional performance with implications of structural performance. Periodic PCI determinations on the same pavement will show the change in performance level with time. The PCI is determined in accordance with procedures contained in ASTM D 5340, *Standard Test Method for Airport Pavement Condition index Surveys*.

b. Advisory Circular 150/5380-7, *Pavement Management System,* outlines the basic concepts of a PMS.

4-7. PAVEMENT PERFORMANCE. The pavement condition survey in conjunction with the PCI may be used to develop pavement performance data. Record distress intensity over time as a means to determine how the pavement is performing. The rate at which the distress intensity increases is a good indicator of the pavement performance.

4-8. PAVEMENT MAINTENANCE MANAGEMENT PROGRAM. Any airport requesting federal funds for a project to replace or reconstruct a pavement, under the airport grant assistance program, must have implemented a pavement maintenance program. Guidance in Appendix 1 contains minimum requirements for such a program.

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CHAPTER 5. MATERIALS AND EQUIPMENT.

5-1. GENERAL. Normal day-to-day pavement maintenance requires only hand tools, but certain specialized equipment may sometimes be needed. Cleaning-out joints in PCC pavements is best accomplished by hand-operated, motor-driven machines especially designed for that purpose. Cracks in asphalt pavements should also be dimensioned to establish proper joint sealant shape. A non-toxic herbicide or other means may be necessary to prevent weeds from growing until sealant materials can be applied. Expedient plow-type devices have also been developed to aid in removing old joint material. Joint sealing can be accomplished by hand pouring from kettles with narrow spouts, but some sealing materials require pressure application and must be applied with specialized equipment.

a. If concrete slabs must be broken, the use of mechanical hammers is recommended. These hammers can also be used for drilling slabs. Precautions should be taken to avoid damaging adjacent slabs.

b. Patching and spot sealing can be expedited by the use of trailer-type asphalt kettles. Those equipped with a powered hand-spray bar are valuable maintenance and repair items.

c. Compaction of asphalt patches and subbase repairs can be accomplished with hand tampers, but better and more uniform results can be ensured if small vibrating compactors are employed. These vibrating compactors are easy to operate, are transportable in small vehicles, can work in very confined areas, and do an excellent job.

d. Large-scale work, for example seal coating of extensive areas, requires specialized equipment such as pressure distributors for bitumen, aggregate spreaders, and rollers. As a general rule, work of this type is performed by contractors or others organized for such large-scale activities.

e. Two to six persons, trained in the various techniques of repairing and familiar with the tools available to them, can perform the routine maintenance required on the pavement surfaces. Work requiring more than such a crew would normally be considered as major repair and will require application of methods, materials, and equipment beyond the normal maintenance requirement.

5-2. COMMON MATERIALS FOR MAINTENANCE AND REPAIR. Materials listed below are commonly used for maintenance and repair of pavements.

a. Bituminous Concrete. Bituminous concrete is a blend of asphalt cement and well-graded, high-quality aggregates. The materials are mixed in a plant and placed and compacted while hot. Bituminous concrete is used for patching and overlay of airfield pavements.

b. Tack Coat. A tack coat is applied to an existing pavement to provide a bond with an overlying course such as a bituminous overlay. A tack coat is also used on the sides of an existing pavement that has been cut vertically prior to patching. Asphalt emulsions are manufactured in several grades and are commonly used for tack coats. Selection of the desired grade is based upon desired setting time.

c. Prime Coat. A prime coat is applied to a non-bituminous base course for the following purposes:

(1) To waterproof the surface of the base

(2) To plug capillary voids

(3) To promote adhesion between the base and the surface course

d. Emulsified or Cutback asphalts are commonly used as a prime coat.

e. Fog Seal. A fog seal is a light application of emulsified asphalt for the purpose or rejuvenating the surface of a bituminous pavement.

f. Aggregate Seal. Aggregate seals consist of sprayed asphalts which are immediately covered with aggregate and rolled and are used to seal the surface of weathered pavements. Aggregate seals are not recommended for airfield pavement due to potential propeller and engine damage caused by loose aggregates.

g. Slurry Seal. A slurry seal is a mixture of a slow-setting asphalt emulsion, fine aggregate, mineral filler, and water. The mixture is prepared in the form of a slurry and applied in a film approximately 1/8 inch (3 mm) thick. Slurry seals are used to seal small cracks, to correct surface conditions, and to improve the skid resistance of pavement surfaces.

h. Coal-Tar Sealer. Coal-tar sealer is a coal-tar base product designed to coat the surface and protect the pavement against fuel spill damage and the intrusion of air and water. It is cold applied and is intended to be periodically reapplied and maintained.

i. Crack Sealing Material. Material for sealing cracks should meet ASTM standards for the type of pavement and service to which the pavement is to be subjected.

j. ASTM D 3405, Joint Sealants, Hot-Poured, For Concrete and Asphalt Pavements, is satisfactory for bituminous concrete and portland cement concrete pavements.

k. ASTM D 3581, Joint Sealants, Hot-Poured, Jet-Fuel Resistant Type, For Portland Cement Concrete and Tar-Concrete Pavements, is satisfactory for areas subject to fuel spillage.

l. Silicone sealants have also been used. Proper use of silicone sealants require that the material modulus be matched to the application.

m. Concrete. Concrete is a blend of portland cement, fine and coarse aggregate, and water, with or without additives. Concrete is used to repair a distressed portland cement concrete pavement so that it may be used at its original designed capacity.

n. Concrete Joint Sealant. Material for sealing joints in both asphalt and portland cement concrete pavement is usually a hot or cold applied compound, meeting the following standards:

(1) ASTM D 1854, Jet Fuel-Resistant Concrete Joint Sealer, Hot-Poured Elastic Type.

(2) ASTM D 3406, Joint Sealants, Hot-Poured, Elastomeric Type for Portland Cement Concrete Pavements.

(3) ASTM D 3569, Joint Sealant, Hot-Poured, Elastomeric, Jet-Fuel Resistant Type for Portland Cement Concrete Pavements.

(4) Federal Specification SS-S-200, Sealing Compounds, Two Component, Elastomeric, Polymer Type, Jet-Fuel Resistant, Cold Applied.

(5) ASTM D 5893, Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements, is satisfactory for Portland cement concrete pavements.

o. Epoxy Grouts and Concretes. There are many types of epoxy resins; the type to be used depends on the application being considered. Under normal conditions, mixed resins may be workable up to one hour after mixing. Repairs with epoxy materials are costly and their use should be limited to small areas and application by experienced personnel.

5-3. EQUIPMENT USE FOR PAVEMENT MAINTENANCE. There are many different types and models of equipment that can be used for pavement maintenance. The equipment types listed below are commonly used by maintenance crews:

a. Pavement Removal.

(1) Power Saws. Pavement power saws are usually one-person-operated, dolly-mounted units that have an abrasive circular blade. These saws are capable of cutting a straight line through asphalt or concrete pavements and leaving vertical sides.

(2) Cutting Disks. Cutting disks are circular, heavy-duty steel plates with a sharpened edge. The disk is usually attached to a motor grader or some other piece of equipment capable of pushing the disk through an asphalt pavement. The cutting disk is much faster than sawing and is recommended where larger areas must be removed; however, it is limited to approximately 3 inches (75 mm) in cutting depth.

(3) Jack Hammers. Jackhammers with a chisel head are commonly used for cutting pavement surfaces.

(4) Pavement Grinders. Pavement grinders are usually one-person-operated, dolly-mounted units that have an abrasive cylindrical head 4 inches (100 mm) or more wide. The grinder may outline an area to be patched by cutting a vertical faced trench into the existing pavement that will anchor the feathered edge of a patch.

(5) Cold Milling Machines. Cold milling machines use a rotating mandrel with cutting bits to remove various depths of pavement material. Bits can be added or removed to vary the cutting width and roughness.. Advantages of cold milling include speed of removal, precision of removal, and grade control.

(5) Hand Tools. Hand tools can be used to make vertical cuts through pavements, as well as to break up deteriorated pavement. Chisels, sledgehammers, shovels, pry bars, and picks are example of this type of equipment.

(6) Front End Loaders and Skid-steer Loaders. Front end loaders are useful in loading trucks when removing old pavement. Skid-steer loaders are small versatile loaders which can be equipped with numerous attachments. Their small size and maneuverability make the ideal for maintenance activities.

(7) Dump Trucks. Dump trucks are used to haul removed pavement and repair materials.

b. Maintenance Equipment.

(1) Asphalt Kettle. Asphalt kettles are usually small tractor mounted units that have a capacity of heating and storing 40 to 500 gallons (.15 m^3 to 2.0 m^3) of bituminous material. A pump forces the liquid material through spray nozzles located on a hand-held hose. These units are used for priming and tacking on small jobs and for crack or surface sealing of bituminous surfaces.

(2) Aggregate Spreaders. Aggregate spreaders can be either truck-mounted or separate units. They are used to evenly place a controlled amount of sand or aggregate on an area.

(3) Hand tools. Rakes, lutes, and other such hand tools are used to move and level material after it has been placed in a patch area.

c. Compaction Equipment.

(1) Vibratory Plate Compactors. Vibratory plate compactors are hand-operated units used to compact granular base or bituminous plant-mix materials.

(2) Vibratory Steel-Wheel Rollers. Vibratory steel-wheel rollers are and are used to compact material, including bituminous concrete in patchwork areas. Smaller rollers can be hand operated while large rollers are self-powered.

(3) Rubber-Tired Rollers - Rubber-tired rollers are self-powered and are used to compact bituminous concrete.

d. Crack and Joint Sealing Equipment.

(1) Joint Plow. A joint plow is used to remove old sealer from joints. This is usually a specially made tool attached to a skid-steer loader.

(2) Joint Router. A joint router is used to clear existing cracks or joints to be resealed. A router is usually a self-powered machine operating a rotary cutter or revolving cutting tool. A rotary routing tool with a V-shaped end can be used for cleaning out random cracks. Rotary cutting tools are not recommended for portland cement concrete pavements.

(3) Power Brush. A power-driven wire brush may be used to clean joints after all of the old joint sealer has been removed.

(4) Air Compressor and Sand Blasting. Sand blasting may be used for final removal of old joint sealant and is recommended as the final cleaning of concrete surfaces prior to application of new sealant. Joints and cracks should be blown out with compressed air immediately prior to application of new sealer. Air compressors should be equipped with oil and moisture traps to prevent contaminating the cleaned surface.

(5) Pavement Sweeper. A pavement sweeper can be used for cleaning the pavement surface and removing excess aggregate. Cleaning operations are necessary in preparation for seal coating and crack filling.

(6) Heating Kettle. A heating kettle is a mobile indirect-fired double boiler used to melt hot applied joint sealing material. It is equipped with a means to agitate and circulate the sealer to ensure uniform heating and melting of the entire charge in the kettle. Sealants may be applied to joints with a pressure base attached directly to a pump unit on the kettle.

(7) Pouring Pot. A pouring pot is hand carried and is used to pour hot sealing materials into a previously prepared crack or joint.

(8) High-pressure water sprayer. A water sprayer can be used to clean out joints prior to resealing, and to clean vertical faces of pavement to be patched.

e. Removal of Pavement Markings

(1) Water jetting. Use of high-pressure water, with proper selection of spray nozzle and pressure, can be highly effective in removal of pavement markings.

(2) Abrasive blasting. Pavement markings can be removed by the impact of edged particles accelerated by pressurized air, although care must be exercised to avoid damage to the pavement surface.

(3) Solvent cleaning. Chemical agents can be employed to remove markings from pavement, with proper attention to environmental concerns and cleanup.

CHAPTER 6. METHODS OF REPAIR.

6-1. GENERAL.

a. Visible evidence of excessive stress levels or environmental distress in pavement systems may include cracks, holes, depressions, and other types of pavement distresses. The formation of distresses in airport pavements may severely affect the structural integrity, ride quality, and safety of airport pavements. To alleviate the effects of distresses and to improve the airport pavement serviceability, an effective and timely maintenance program and adequate repair procedures should be adopted.

b. In all cases of pavement distress, the first step in rehabilitating a pavement should be to determine the causes of distress. Then, the proper procedures for repair, which will not only correct the damage but will also prevent or retard its further occurrence, may be applied. Pavement repairs should be made as quickly as possible after the need for them is assessed so that continued and safe aircraft operations can be ensured. While deterioration of the pavements due to traffic and adverse weather conditions cannot be completely prevented, maintenance and repair programs can significantly reduce the rate of deterioration and limit deterioration to a minimum level.

c. Repair measures to prevent further pavement damage may be limited by weather conditions. For example, rehabilitation by crack filling is more effective in cool and dry weather conditions, whereas pothole patches adhere best during warm and dry days. In addition, seal coats and other surface treatments require warm and dry weather for best results. This does not mean that resurfacing work cannot be performed under cold and damp conditions. Rather, these repairs require much greater care when made during such periods. Another important consideration is the timeliness of the repair. Perform repairs at early stages of distress, even when they may be considered minor. A delay in repairing pavements may allow minor distresses to progress into major failures.

d. The minimum depth for material removal and saw cuts for PCC should be 50mm (2") if repairs are to be made using any PCC or bituminous material. Repairs made thinner than 50mm usually deteriorate quickly on an airfield pavement. (Most distresses needing repair will extend at least 50mm into the pavement.) Epoxy materials may be beneficial where a repair thinner than 50mm is necessary.

6-2. REPAIR METHODS FOR PORTLAND CEMENT CONCRETE PAVEMENTS.

a. Crack Repair and Sealing. Seal cracks to prevent surface moisture from entering the pavement structure. Seal cracks only after a properly shaped sealant reservoir is established. Establish reservoir dimensions by sawing and not by router equipment as routers use a mechanical impact to remove material and can cause micro-cracks in the concrete.

(1) Longitudinal, Transverse, and Diagonal Cracks.

(a) Saw a groove to the width and depth recommended by the sealant manufacturer. Generally, hot pour materials need a width equal to the depth. The width needs to be sufficient to allow the material to stretch and contract with movement in the pavement. Common hot-pour materials recommend a 1/2 inch groove width (10 mm). Silicone materials typically require a width twice the dimension of the depth. Widths smaller than 3/8 inch are not recommended due to difficulties inserting the sealant material.

(b) Sand blast both sides of the sealant reservoir and clean out with compressed air. The groove must be dry and free of dirt, dust, or other material that might prevent bonding of the sealant.

(c) Place a bond breaker at the proper depth to establish the joint sealant reservoir. Bond breakers are necessary to prevent bonding of the sealant material to the bottom of the crack. Improper bonding restricts the movement of the sealant material and can cause premature failure. Backer rod is a common material used to prevent bond and to establish the proper joint reservoir dimensions. Backer Rod is an extruded, chemically inert, closed cell polyethylene "rope" designed to effectively fill in the gaps in the joint. The backer rod is sized slightly larger than the width of the joint and is simply pushed to the desired depth.

(d) Fill the joint reservoir with sealant. Sealant should not extend above the pavement surface. Excess sealant on the pavement surface does not assist in sealing the crack and is prone to tracking and damage from wheels and snow removal equipment.

(2) Corner Cracks. Use the following procedure to repair corner cracks accompanied by loss of subgrade support. For low severity cracks, the procedure for crack sealing should be used. Note that rebar or dowels could be added to the corners. In some instances, where the broken corner is large enough to permit installation, the use of drilled-in dowels or rebars can help reduce future corner damage in the same location.

(a) Make a vertical cut with a concrete saw and break out the broken corner to establish an approximately square repair area.

(b) Add subbase material, if necessary, and compact.

(c) Clean the vertical faces of the remainder of the slab with a high-pressure water jet or compressed air.

(d) Coat the faces of the adjacent slabs with a bond-breaking medium to prevent bonding of the new concrete.

(e) Maintain the existing joint by using temporary inserts or by sawing the required joint dimensions. Failure to maintain the existing joint width may result in spalling or crushing of the concrete at the joint. Even small areas where the new concrete is allow to directly contact the existing concrete across a joint can result in spalling or crushing of the concrete.

(f) Drill and epoxy dowels or tie-bars if used.

(g) Coat the clean vertical cut with sand-cement grout or epoxy grout.

(h) Place the portland cement concrete in the patch area while the grout is still tacky.

(i) After the concrete has cured, establish the proper joint reservoir shape by removing joint inserts and sawing the joint reservoir.

(j) Seal joints.

(3) "D" Cracking. The repair of this type of distress usually requires that the complete slab be repaired since "D" cracking will normally re-appear adjacent to the repaired areas. Temporary repairs can be made using the technique noted in paragraph 6-2b(1).

(4) Joint Seal Damage. The sequence of operations for preparing joints for resealing is as follows:

(a) Use joint plow, or diamond saw blade to remove the joint sealing material to a depth of at least 1 inch (25 mm) or to the full depth of the reservoir for contraction and construction joints.

(b) Reface the side of the joint to expose sound concrete that is free of old sealer. This may be accomplished with a power saw.

(c) Clean the joint reservoir. If a saw was used to reface the joint, flush with water immediately after sawing. Remove any remaining debris by sand blasting or power brush.

(d) Immediately prior to sealing, blow out the joint with compressed air to remove sand, dirt, and dust.

(e) Install new dry backer rod.

(f) Seal joints with hot or cold compounds. Hot poured sealants should be injected into the joint through nozzles shaped to penetrate into the joint and fill the reservoir from the bottom. On small jobs, hand-pouring pots may be used.

b. Disintegration. If not impeded in its early stages, disintegration can progress rapidly until the pavement requires complete rebuilding.

(1) Scaling, Map Cracking, and Crazing.

(a) Make a vertical cut with a concrete saw about 1 to 2 inches (25 to 50mm) deep at the perimeter of the scaled area.

(b) Break out the broken concrete with pneumatic tools until sound concrete is exposed.

(c) Clean the area with compressed air or high-pressure water jet.

(d) Coat the surface of the old concrete with a thin coat of sand-cement grout. Dampen surface with water before applying the grout.

(e) Place the portland cement concrete while the grout is still tacky.

(f) If the patch crosses or abuts a working joint, the joint must be continued through the patch.

(2) Joint Spalling and Corner Spalling. The procedure for repair of spalls is as follows:

(a) Make a vertical cut with a concrete saw 2 inch (50 mm) in depth and approximately 2 inches (50 mm) back of the spalled area.

(b) Break out the unsound concrete with air hammers or pneumatic drills and blow out the area with compressed air.

(c) Pressure rinse the area to be repaired. Allow patch area to dry completely if required by the patch material specification.

(d) Treat the surface with a grout mixture to ensure a good bond between the existing pavement and the new concrete. Apply the grout immediately before placing the patch mixture and spread with a stiff broom or brush to a depth of 1/16 inch (2 mm).

(e) Place a thin strip of wood or metal coated with bond-breaking material in the joint groove and tamp the new mixture into the old surface. The mix should be air-entrained and designed to produce a no slump concrete which will require tamping to place in the patch.

(f) After edging of the patch has been completed, it should be finished to a texture matching the adjacent area.

(g) After curing for a minimum of 3 days, and fill the open joint with joint sealant prior to opening to traffic.

(3) Crack Spalling. The procedure is the same as for joint spalling except for the joint repair.

(4) Blowups. Blowups may be repaired using the following procedures:

(a) Make a vertical cut with a concrete saw approximately 6 inches (150 mm) outside of each end of the broken area.

(b) Break out the concrete with pneumatic tools and remove concrete down to the subbase/subgrade material.

(c) Add subbase material, if necessary, and compact.

(d) In reinforced pavement construction, joint techniques should be used to tie the new concrete to the old reinforced material. Any replacement joints should be doweled and built to joint specifications. For simplicity of construction, all tiebars, dowels, and reinforcement may be omitted from small interior pavement patches on well-compacted subgrades.

(e) Dampen the subgrade and the edges of the old grout.

(f) Place concrete on the area to be patched.

(g) Use ready-mixed concrete if it is satisfactory and can be obtained economically. It may be desirable to use a mixture providing high early strength in order to permit the earliest possible use.

(h) Finish the concrete so that the surface texture approximates that of the existing pavement.

(i) Immediately after completion of finishing operations, the surface should be properly cured. Either a moist cure or a curing compound may be used.

(5) Shattered Slab. A shattered slab requires that the full slab be replaced. Follow the same procedure for blowup repairs except that unstable subgrade materials should be removed and replaced with select material. Poor drainage conditions should be corrected by the installation of drains for removal of excess water.

c. Distortion. If not too extensive, some forms of distortion such as from settlement can be remedied by raising the slab to the original grade. Slabjacking procedures may be used to correct this type of distress. In slabjacking, a grout is pumped under pressure through holes cored in the pavement into the void under the pavement. This creates an upward pressure on the bottom of the slab in the area around the void. The upward pressure lessens as the distance from the grout hole increases. Thus, it is possible to raise one corner of a slab without raising the entire slab. Because of special equipment and experience required, slabjacking is usually best performed by specialty contractors.

d. Loss of Skid Resistance. Treatment includes resurfacing, grooving, milling, and surface cleaning.

(1) Polished Aggregate. Since polished aggregate distress normally occurs over an extensive area, grooving or milling of the entire pavement surface should be considered. Concrete or bituminous resurfacing may also be used to correct this condition.

(2) Contaminants. Rubber deposits may be removed by use of high-pressure water or biodegradable chemicals.

6-3. TEMPORARY PATCHING OF CONCRETE PAVEMENTS. Broken concrete areas can be patched with bituminous concrete as an interim measure. Repair for corner cracks, diagonal cracks, blowups, and spalls can be made using the following procedure:

a. Make a vertical cut with a concrete saw completely through the slab.

b. Break out the concrete with pneumatic tools and remove broken concrete down to the subbase/subgrade material.

c. Add subbase/subgrade material if required and compact.

d. Apply prime coat to subbase material.

e. Apply tack coat to the sides of the slab.

f. Place bituminous concrete in layers not exceeding 3 inches (75 mm).

g. Compact each layer with a vibratory-plate compactor, roller, or mechanical rammers. For partial depth repairs make a vertical cut approximately 3 inches (75 mm) deep, apply tack coat and place bituminous concrete in one layer.

Normal traffic may be permitted on bituminous patches immediately after completion of the patch.

6-4. REPAIR METHODS FOR BITUMINOUS CONCRETE PAVEMENTS.

a. Crack Sealing. Cracking takes many forms. In some cases, simple crack filling may be the proper corrective action. In others, complete removal of the cracked area and the installation of drainage may be necessary.

(1) Longitudinal, Transverse, Reflection, and Block Cracking. Narrow cracks, less than 1/4 inch (6 mm), are too small to seal effectively. In areas where narrow cracks are present, a seal coat, slurry seal, or fog coat may be applied. Narrow cracks can also be widened by sawing or routing. Wide cracks, greater than 1/4 inch (6 mm), should be sealed using the following procedure:

(a) Clean out crack with compressed air to remove all loose particles. Note that routing to widen the crack prior to utilizing compressed air may be necessary. Also, any required weed prevention should be addressed.

(b) Fill cracks with a prepared crack sealer.

(2) Alligator Cracking. Permanent repairs by patching may be carried out as follows:

(a) Remove the surface and base as deep as necessary to reach a firm foundation. In some cases, a portion of the subgrade may also have to be removed. A power saw should be used to make a vertical cut through the pavement. The cut should be square or rectangular.

(b) Replace base material with material equal to that removed. Compact each layer placed. Naturally, if the base material has proved problematic, it must be replaced with a more appropriate material.

(c) Apply tack coat to the vertical faces of existing pavement.

(d) Place bituminous concrete and compact.

(3) Slippage Cracks. One repair method commonly used for slippage cracks involves removing the affected area and patching with plant-mixed asphalt material. Specific steps are given below:

(a) Remove the slipping area and at least 1 foot (300 mm) into the surrounding pavement. Make the cut faces straight and vertical. A power pavement saw makes a fast and neat cut.

(b) Clean the surface of the exposed underlying layer with brooms and compressed air.

(c) Apply a light tack coat.

(d) Place sufficient hot plant-mixed asphalt material in the cutout area to make the compacted surface the same grade as that of the surrounding pavement.

(e) Compact the asphalt mixture with steel-wheel or rubber-tire rollers until the surface is the same elevation as the surrounding pavement.

b. Disintegration. If not impeded in its early stages, disintegration can progress rapidly until the pavement requires complete rebuilding. Sealer-rejuvenator products can be applied as a measure to halt disintegration. The products help reverse the aging process of the surface asphalt. Deterioration from raveling may be also be impeded by using the following procedures:

(1) Sweep the surface free of all dirt and loose aggregate material.

(2) Apply a fog seal diluted with equal parts of water.

(3) Close to traffic until the seal has cured.

(4) Apply a surface treatment such as an aggregate seal coat.

(5) A pavement planing machine, such as a heater-plane, may be used to soften the surface of the pavement prior to applying a seal coat or bituminous concrete overlay. However, use of a heater-planer can damage the existing pavement and some contribution to air pollution can result.

c. Distortion. Repair techniques range from leveling the surface by filling with new material to complete removal of the affected area and replacing with new material. Cold milling can be employed prior to overlaying for many of these distresses:

(1) Rutting. Repair procedures are as follows:

(a) Determine the severity of the rutting with a straightedge or stringline. Outline the areas to be filled.

(b) Apply a light tack coat of asphalt emulsion diluted with equal parts of water.

(c) Spread dense-graded asphalt concrete with a paver and compact. Be sure that the material is feathered at the edges.

(d) Place a thin overlay of bituminous concrete over the entire area.

(e) To repair only the rut, where an overlay is not warranted, grind the area or sawcut to produce a vertical edge for placement of repair material to restore proper line and grade. This will result in a more durable patch.

(2) Corrugation and Shoving. The repair procedure for this type of distress is the same as for patch repair of alligator cracking.

(3) Depressions. Repair procedures are as follows:

(a) Determine the limits of the depression with a straightedge or stringline. Outline the depression on the pavement surface.

(b) Mill or grind down the area to provide a vertical face around the edge. This step may be omitted, however the resulting repair will not be as successful.

(c) Thoroughly clean the entire area to at least 1 foot (250 mm) beyond the marked limits.

(d) Apply a light tack coat of asphalt emulsion diluted with equal parts of water to the cleaned area.

(e) Spread enough bituminous concrete in the depression to bring it to the original grade when compacted. The correct way to repair a deep depression is to begin in the deepest part of the depression and place a thin layer, the surface of which, when compacted, will be parallel to the original pavement surface. Successive layers are placed in the same manner.

(f) If the pavement was not ground down, the edges of the patch should be feathered by careful raking and manipulation of the material. However, in raking, care should be taken to avoid segregation of the coarse and fine particles of the mixture. With additional effort, a more suitable and longer lasting patch can result by grinding the edges down or sawing and using light jackhammer to create a vertical edge resulting in no featheredge where little raking is required.

(g) Thoroughly compact the patch with a vibratory-plate compactor, roller, or hand tamps.

e. Swelling. The repair procedure is the same as for patch repair of alligator cracking.

f. Loss of Skid Resistance. Treatment includes removal of excess asphalt, resurfacing, grooving to improve surface drainage, and removal of rubber deposits.

(1) Bleeding. Repair procedures using hot sand or aggregate are as follows:

(a) Apply slag screenings, sand, or rock screenings to the affected area. The aggregate should be heated to at least 300 F (150 C) and spread at the rate of 10 to 15 pounds per square yard (4 to 9 kg per square meter).

(b) Immediately after spreading, roll with a rubber-tired roller.

(c) When the aggregate has cooled, broom off loose particles.

(d) Repeat the process, if necessary.

(e) A pavement planing machine, such as a heater-planer, may be used to remove the excess asphalt; specifically:

(i) Remove the asphalt film with a heater-planer.

(ii) Leave the surface as planed; or

(iii) Apply either a plant-mixed surface treatment or a seal coat.

(iv) A pavement milling machine may be used to remove excess asphalt by milling off 1/8 inch to 1/4 inch of pavement.

(2) Polished Aggregate. One means of correcting this condition is to cover the surface with an aggregate seal coat. Grooving, milling or diamond grinding the pavement surface may also be used.

(3) Fuel Spillage. Permanent repairs for areas subjected to continuous fuel spillage consist of removal of the damaged pavement and replacement with portland cement concrete or bituminous asphalt with a coal-tar emulsion seal coat.

(4) Contaminants. Rubber deposits may be removed by use of high-pressure water or biodegradable chemicals.

6-5. ADDITIONAL REPAIR METHODS. Detailed procedures for bituminous concrete repairs are contained in "MS-16, Asphalt in Pavement Maintenance," published by The Asphalt Institute. Detailed procedures for portland cement concrete pavement repairs are contained in the following publications available from the Portland Cement Association: "Maintenance of Joints and Cracks in Concrete Pavement." "Patching Concrete Pavements," and "Cement Grout Subsealing and Slab-Jacking of Concrete Pavement." (See Appendix 2) A summary of maintenance and repair procedures for rigid and flexible pavement is contained in Table1.

TABLE 1. MAINTENANCE AND REPAIR OF PAVEMENT SURFACES.

PROBLEM	PROBABLE CAUSE	REPAIR
Crack and joint sealer missing or not bonded to slabs	Faces of joints (cracks) not clean when filled; incorrect application temperature of sealer; wrong kind of seal material; improper joint width.	Remove old material sealer if extensive areas affected; sandblast joints and cracks; reseal properly.
Random cracking	Uncontrolled shrinkage (improper joint spacing); overstressed slabs; slab support lost; subgrade settlement; bitumen too hard or overheated in mix.	Seal newly formed cracks; replace subbase to establish support; if pavement being overloaded, probably will require overlay.
Surface scaling or breakup	**In PCC** - Overworked finishing operation; inadequate curing. **In Flexible Pavement** - Overheated binder; poor aggregate gradation; insufficient binder; incorrect binder or aggregate; fuel spillage, stripping.	**In PCC** - Remove and replace panel; resurface with thin bonded concrete; resurface area with a bituminous concrete. **In Flexible Pavement** - Apply seal coat; overlay.
Joint (1) faulting or (2) spalling	Variable support for unbonded slabs; loss of load transfer capability. Incompressible matter in joint spaces; excessive joint finishing.	Remove problem slab; replace slab (dowel to existing pavement). Clean joint; refill with bituminous-sand mix; reseal.
Pumping	Saturated pavement foundation; lack of subbase.	Prevent entrance of water (correct the drainage problem); pump slurry under slabs to reseal; replace slabs and slab foundation; install drainage.
Surface irregularities (rutting, washboarding, birdbaths, undulations)	**In PCC** - Poor placing control; broken slabs; poor finishing. **In Flexible Pavement** - Nonuniform settlement from inadequate compaction of pavement components or fill unstable mix (poor aggregate gradation, too rich, etc.); poor laying control.	**In PCC** - Patch local areas, or overlay if widespread. **In Flexible Pavement** - Patch local areas; apply leveling course; roto-mill.
Bleeding of bituminous binder	Too much binder in mix (over rich mix).	Scrape off excess material; blot with sand. NOTE: Bleeding is usually an indication that other surface deformities (rutting, washboarding, etc.) will occur.
Potholes	Water entering pavement structures; segregation in base course material.	Remove and replace base (and subbase if required); replace surface and seal.
Oxidation of bituminous binder	Lack of timely seal coat; binder overheated in mixing; wrong grade of asphalt for climate.	Apply seal coat; heater planer; resurface.
Map cracking, Crazing, Alligator cracking	**In PCC** - Excessive surface finishing; Alkali-Aggregate Reactivity. **In Flexible Pavement** - Overload; oxidized binder; under-designed surface course (too thin).	**In PCC** - If surface deforms or breaks, resurface, grind. **In Flexible Pavement** - Overlay; apply seal coat.
Popouts at joints	Dowel misaligned.	Fill popout hole with bituminous concrete or bituminous sand mix (if recurring, may require replacement of slabs).
Slab "blowup"	Incompressible material in joints preventing slab from expanding; Alkali-Aggregate Reactivity.	Replace slab in blowup area; clean and reseal joints.
Slipperiness	**In PCC** - Improper finish (too smooth); type of curing membrane; excessive curing membrane; polished aggregate, rubber deposits. **In Flexible Pavement** - Over rich mix; poorly designed mix; polished aggregate; improperly applied seal coat; wrong kind of seal coat; rubber deposits.	**In PCC** - If finish too smooth, resurfacing required to provide texture; wire broom to remove curing membrane; grooving; remove rubber. **In Flexible Pavement** - Apply textured seal coat; grooving; remove rubber.

APPENDIX 1. PAVEMENT MAINTENANCE MANAGEMENT PROGRAM.

An effective Pavement Maintenance Management Program is one that details the procedures to be followed to assure that proper pavement maintenance, both preventive and remedial, is performed. An airport sponsor may use any form of inspection program it deems appropriate. The program must, as a minimum, include the following:

1. Pavement Inventory. The following must be depicted in an appropriate form and level of detail:

- **a.** Location of all runways, taxiways, and aprons
- **b.** Dimensions
- **c.** Type of pavement
- **d.** Year of construction or most recent major rehabilitation

For compliance with the Airport Improvement Program assurances, pavements that have been constructed, reconstructed, or repaired with Federal financial assistance shall be so depicted.

2. Inspection Schedule.

a. Detailed Inspection. A detailed inspection must be performed at least once a year. If a history of recorded pavement deterioration is available, i.e. Pavement Condition Index (PCI) survey as set forth in ASTM D5340, Standard Test Method for Airport Pavement Condition Index Surveys, the frequency of inspections may be extended to three years.

b. Drive-by Inspection. A drive-by inspection must be performed a minimum of once per month to detect unexpected changes in the pavement condition.

3. Record Keeping. Complete information on the findings of all detailed inspections and on the maintenance performed must be recorded and kept on file for a minimum of five years. The types of distress, their locations, and remedial action, scheduled or performed, must be their locations, and remedial action, scheduled or performed, must be documented. The minimum information to be recorded is listed below.

- **a.** inspection date
- **b.** location
- **c.** distress types
- **d.** maintenance scheduled or performed

For drive-by inspections, the date of inspection and any maintenance performed must be recorded.

4. Information Retrieval. An airport sponsor may use any form of record keeping it deems appropriate, so long as the information and records produced by the pavement survey, can be retrieved to provide a report to the FAA as may be required.

5. Program Funding. Identify funding and other resources available to provide remedial and preventive maintenance activities.

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